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The problem that I solved is the lack of a method and validated measurements that allow software engineers to measure the quality of OO code. Software quality is composed of two collections of attributes, directly and indirectly measurable. In this study, directly measurable attributes were computed by inspecting the static code. The problem with the measurements proposed to date in the literature has been the lack of validation for their use with OO code. In addition, the literature does not contain definitions of a validated method for measuring the indirectly measurable quality attributes (or attributes that cannot be measured by an inspsection or study of the static code), such as reusability. During the Fall Semester 1996, I made some progres in validating the empirical study instrument (il.e. the scale or the survey). I am planning, under the continued direction of Dr Rine, to present and defend my research results by the Summer of 1997.

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FINAL
~~PROGRESS~~ REPORT

Submitted to

The General Contracting Office

of the AFOSR

by

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SPRING 1997

1. Introduction

The problem that I propose to solve is the lack of a method and validated measurements that allow software engineers to measure the quality of OO code. Software quality is composed of two collections of attributes, directly and indirectly measurable. In this study, directly measurable attributes are computed by inspecting the static code. The problem with the measurements proposed to date in the literature has been the lack of validation for their use with OO code. In addition, the literature does not contain definitions of a validated method for measuring the indirectly measurable quality attributes (or attributes that cannot be measured by an inspection or study of the static code), such as reusability.

During the Fall Semester 1996, I made some progress in validating the empirical study instrument (i.e. the scale or the survey). I am planning, under the continued direction of Dr. Rine, to present and defend my research results by the Summer of 97. The remainder of this report contains a statement of the research goals and a presentation of the scale validation.

2. Goals

This research is aimed at achieving two goals:

I. The first goal is concerned with direct quality attribute measurement:

   A. To identify a set of measurements that may be used by software engineers to automatically and directly measure static and syntactic attributes of Object-Oriented code components.

   B. To provide a set of abstract conditions that permit the formal comparison of OO measurements that directly measure static and syntactic attributes of OO code components.

   C. To provide analytical and empirical proof of the validity of measurements that directly measure static and syntactic attributes of OO code components.

II. The second goal is concerned with measuring indirect quality attributes: To provide software engineers with an empirically validated method for evaluating Object-Oriented code components. This method will allow the assessment of indirectly measurable quality attributes through the automatic measurement of direct quality attributes.

3. Accomplished Goals:

1. To identify and validate measurements for direct quality attributes of OO software.

2. To measure direct quality attributes of some OO software.

3. To identify a measure or scale for quantifying indirect quality attributes.

4. To assess indirect quality attributes of the same OO software used in step 2 above.

5. To validate the scale used to measure indirect quality attributes by means of statistical analysis of the measurements resulting from the use of the scale defined in step 3 above, and to interpret the results (the validation follows in section 5).

4. Goals In-Progress:

6. Interpretation of results, and

7. Recommendations.

5. Goal 5 Validation

The method that was used to validate the scale construct consisted of correlating the groups of questions in the survey that were designed to measure different aspects of the same indirect quality attribute. The following subsections consist of a listing of the questions that appeared in the survey. Each group of questions that was designed to gauge a certain indirect attribute appears in a separate subsection. The correlation coefficients that were computed for each group appear next. Three sets of correlation coefficients appear for each class used in the survey. The first three sets consist of data gathered for the class Conductor (scientific computation domain). The second three sets consist of data gathered for the class XYPlot (GUI domain). This separation was necessary because some attributes are expected to have high measures for one but not for the other domain (e.g. portability). For each domain, the 3 sets of data represent:

1) all the responses corresponding to that domain,
2) the sorted responses for respondents whose C++ programming experience is stated as 2 (intermediate), and whose level of expertise in the domina is either 2 or 3 (somewhat experienced or experienced), and,
3) sorted responses for respondents whose C++ programming experience is stated as 3 (experienced), and whose level of expertise in the domina is either 2 or 3 (somewhat experienced or experienced).

This stratification of the data was necessary because the data that was collected from inexperienced respondents was found to be inconsistent with the responses gathered from the other two groups.

At the end of each indirect quality attribute subsection, a table appears that shows a matrix for correlation coefficients computed by the package SPSS for each indirect quality attribute. The lower triangle contains an A (All) if responses for both domains show a correlation, AG (All GUI) indicates a correlation between GUI responses, AC (All Scientific Computation) indicates a correlation between Scientific Computation responses, and C2, C3, or G2, G3 indicate correlations appearing among responses given by somewhat experienced or experienced programmers in the Scientific Computation or GUI domains respectively.

An initial evaluation shows that various aspects of each attribute (e.g. aspects GEN1, GEN2, & GEN3 for the attribute Generality) are indeed correlated. Further analysis of the correlations was conducted where inconsistencies appeared. This analysis, if applicable, appears at the end of the subsection.

5.1 Attribute Correlations

A. ADAPTABILITY:

ADAP1

1. It is easy to expand the class to add new user requirements.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1** Strongly Disagree **0** Not Applicable

ADAP2

2. It is easy to modify the class to meet changing user needs.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1** Strongly Disagree **0** Not Applicable

ADAP3

3. It is easy to modify the class to meet differing system constraints.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1** Strongly Disagree **0** Not Applicable

ADAP4

4. The class implementation is dependent on certain storage requirements.

1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

ADAP5

5. All dependencies on outside resources are properly documented within the class definition.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1** Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All responses

-- Correlation Coefficients --

	ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1	1.0000	.8927	.6134	.1520	.0828
	(32)	(31)	(31)	(31)	(32)
	P= .	P= .000	P= .000	P= .207	P= .326
ADAP2	.8927	1.0000	.6654	.0908	.2313
	(31)	(32)	(31)	(31)	(32)
	P= .000	P= .	P= .000	P= .314	P= .101
ADAP3	.6134	.6654	1.0000	-.1259	.0680
	(31)	(31)	(32)	(31)	(32)
	P= .000	P= .000	P= .	P= .250	P= .356
ADAP4	.1520	.0908	-.1259	1.0000	.0896
	(31)	(31)	(31)	(32)	(32)
	P= .207	P= .314	P= .250	P= .	P= .313
ADAP5	.0828	.2313	.0680	.0896	1.0000
	(32)	(32)	(32)	(32)	(33)
	P= .326	P= .101	P= .356	P= .313	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3

-- Correlation Coefficients --

	ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1	1.0000	.8324	.5806	.2037	-.0325
	(16)	(16)	(16)	(16)	(16)
	P= .	P= .000	P= .018	P= .449	P= .905
ADAP2	.8324	1.0000	.6214	.0404	.0348
	(16)	(16)	(16)	(16)	(16)
	P= .000	P= .	P= .010	P= .882	P= .898
ADAP3	.5806	.6214	1.0000	-.1597	-.0626
	(16)	(16)	(16)	(16)	(16)
	P= .018	P= .010	P= .	P= .555	P= .818
ADAP4	.2037	.0404	-.1597	1.0000	-.4174
	(16)	(16)	(16)	(16)	(16)
	P= .449	P= .882	P= .555	P= .	P= .108
ADAP5	-.0325	.0348	-.0626	-.4174	1.0000
	(16)	(16)	(16)	(16)	(16)
	P= .905	P= .898	P= .818	P= .108	P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1	1.0000	.9818	.6550	-.0852	.0226
	(9)	(9)	(9)	(8)	(9)
	P= .	P= .000	P= .056	P= .841	P= .954
ADAP2	.9818	1.0000	.6695	.0357	.1371
	(9)	(10)	(10)	(9)	(10)
	P= .000	P= .	P= .034	P= .927	P= .706
ADAP3	.6550	.6695	1.0000	-.1130	-.0071
	(9)	(10)	(10)	(9)	(10)
	P= .056	P= .034	P= .	P= .772	P= .984
ADAP4	-.0852	.0357	-.1130	1.0000	.6614
	(8)	(9)	(9)	(9)	(9)
	P= .841	P= .927	P= .772	P= .	P= .052
ADAP5	.0226	.1371	-.0071	.6614	1.0000
	(9)	(10)	(10)	(9)	(10)
	P= .954	P= .706	P= .984	P= .052	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1	1.0000	.8512	.1192	.3646	-.4117
	(26)	(26)	(26)	(22)	(26)
	P= .	P= .000	P= .281	P= .048	P= .018
ADAP2	.8512	1.0000	.1049	.1148	-.4928
	(26)	(26)	(26)	(22)	(26)
	P= .000	P= .	P= .305	P= .305	P= .005
ADAP3	.1192	.1049	1.0000	.5893	.3907
	(26)	(26)	(26)	(22)	(26)
	P= .281	P= .305	P= .	P= .002	P= .024
ADAP4	.3646	.1148	.5893	1.0000	.2613
	(22)	(22)	(22)	(22)	(22)
	P= .048	P= .305	P= .002	P= .	P= .120
ADAP5	-.4117	-.4928	.3907	.2613	1.0000
	(26)	(26)	(26)	(22)	(26)
	P= .018	P= .005	P= .024	P= .120	P= .

(Coefficient / (Cases) / 1-tailed Significance)

" . " is printed if a coefficient cannot be computed

GUI 2-2/3 -- Correlation Coefficients --

	ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1	1.0000	.8700	-.2530	.7859	-.3435
	(13)	(13)	(13)	(9)	(13)
	P= .	P= .000	P= .404	P= .012	P= .250
ADAP2	.8700	1.0000	-.1502	.7819	-.2228
	(13)	(13)	(13)	(9)	(13)
	P= .000	P= .	P= .624	P= .013	P= .464
ADAP3	-.2530	-.1502	1.0000	.6548	.7854
	(13)	(13)	(13)	(9)	(13)
	P= .404	P= .624	P= .	P= .056	P= .001
ADAP4	.7859	.7819	.6548	1.0000	.3833
	(9)	(9)	(9)	(9)	(9)
	P= .012	P= .013	P= .056	P= .	P= .308
ADAP5	-.3435	-.2228	.7854	.3833	1.0000
	(13)	(13)	(13)	(9)	(13)
	P= .250	P= .464	P= .001	P= .308	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3 -- Correlation Coefficients --

	ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1	1.0000 (8) P= .	.8189 (8) P= .013	.8737 (8) P= .005	.4364 (8) P= .280	-.0867 (8) P= .838
ADAP2	.8189 (8) P= .013	1.0000 (8) P= .	.7538 (8) P= .031	.1443 (8) P= .733	-.3441 (8) P= .404
ADAP3	.8737 (8) P= .005	.7538 (8) P= .031	1.0000 (8) P= .	.5222 (8) P= .184	-.0692 (8) P= .871
ADAP4	.4364 (8) P= .280	.1443 (8) P= .733	.5222 (8) P= .184	1.0000 (8) P= .	.0000 (8) P=1.000
ADAP5	-.0867 (8) P= .838	-.3441 (8) P= .404	-.0692 (8) P= .871	.0000 (8) P=1.000	1.0000 (8) P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:

There exists some correlation between ADAP1 & ADAP2.
There exists some correlation between ADAP1 & ADAP3.
There exists some correlation between ADAP2 & ADAP3.

There exists some correlation between ADAP4 & ADAP5 only among answers given by respondents who listed their C++ programming experience level as 3, and their scientific computation programming experience level as 2 or 3.

2. For the class XYPlot:

There exists some correlation between ADAP1 & ADAP2.
There exists some correlation between ADAP3 & ADAP4.

There exists some correlation between ADAP1 & ADAP4, ADAP2 & ADAP4, ADAP3 & ADAP5 only among answers given by respondents who listed their C++ programming experience level as 2, and their GUI programming experience level as 2 or 3.

There exists some correlation between ADAP1 & ADAP3, ADAP2 & ADAP3, only among answers given by respondents who listed their C++ programming experience level as 3, and their GUI programming experience level as 2 or 3.

There exists some correlation between ADAP1 & ADAP3 only among answers given by respondents who listed their C++ programming experience level as 3, and their GUI programming experience level as 2 or 3.

These results are summarized in the table below:

ADAP1	ADAP2	ADAP3	ADAP4	ADAP5
ADAP1				
ADAP2	A			
ADAP3	A	A		
ADAP4	G2	G2	AG	
ADAP5			G2	C3

Analysis: The attribute Adaptability is defined by NIST as:

- The ease with which software can accommodate to change.
- The ease with which software can be modified to meet new requirements.
- The ease with which a system or component can be modified for use in applications or environments other than those for which it was specifically designed.
- The ease with which software allows differing system constraints and user needs to be satisfied.

In addition, the processing performed by a module should be independent of storage size, buffer space, array sizes, etc. Provisions for these entities should be provided dynamically, e.g. array sizes passed as parameters.

An examination of the survey Adaptability questions listed below helps to explain the adaptability correlations. That is correlations exist between all aspects of adaptability (desired) except those between ADAP1 & ADAP5 and ADAP2 & ADAP5. Further examination of the class texts reveals that both contain "include" statements to other classes that the respondents did not have access to. This lack of explanation of what functions these other classes perform helps explain this low correlation. In other words, the respondents while agreeing that the class is easy to change and modify, (this means that they can clearly understand its purpose, and that it is a well defined class), the lack of documentation resulted in a low score for the documentation level. in retrospect it seems that this question was misstated (emphasis is on documentation levels as opposed to dependance on outside resource levels), or does not belong in the adaptability category.

B. COMPLETENESS

COMP1

6. The name of the class is synonymous with the real-world object you had perceived this class to represent.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1** Strongly Disagree **0** Not Applicable

COMP2

7. Based on what you perceive to be the base-line functionality of the real-world object (what the class should do, as opposed to a "would be nice to have"), the class meets all your requirements.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1** Strongly Disagree **0** Not Applicable

COMP3

8. It is possible to remove methods from the class definition without diminishing the functionality normally associated with the real world object that this class represents.

1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

COMP4

9. It is possible to add methods to this class definition without adding functionality that would not normally be associated with the real world object that this class represents.

1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

COMP5

10. Each method in the class consists of code that implements one function.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All Responses

-- Correlation Coefficients --

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1	1.0000	.2825	.3803	.1337	.4209
	(33)	(33)	(33)	(33)	(33)
	P= .	P= .056	P= .015	P= .229	P= .007
COMP2	.2825	1.0000	.2353	.4414	.5654
	(33)	(33)	(33)	(33)	(33)
	P= .056	P= .	P= .094	P= .005	P= .000
COMP3	.3803	.2353	1.0000	.2752	.1242
	(33)	(33)	(33)	(33)	(33)
	P= .015	P= .094	P= .	P= .061	P= .246
COMP4	.1337	.4414	.2752	1.0000	.0927
	(33)	(33)	(33)	(33)	(33)
	P= .229	P= .005	P= .061	P= .	P= .304
COMP5	.4209	.5654	.1242	.0927	1.0000
	(33)	(33)	(33)	(33)	(33)
	P= .007	P= .000	P= .246	P= .304	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3 -- Correlation Coefficients --

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1	1.0000	.2420	-.0040	-.0649	.5086
	(16)	(16)	(16)	(16)	(16)
	P= .	P= .367	P= .988	P= .811	P= .044
COMP2	.2420	1.0000	.0103	.2953	.4258
	(16)	(16)	(16)	(16)	(16)
	P= .367	P= .	P= .970	P= .267	P= .100
COMP3	-.0040	.0103	1.0000	.1794	-.4323
	(16)	(16)	(16)	(16)	(16)
	P= .988	P= .970	P= .	P= .506	P= .094
COMP4	-.0649	.2953	.1794	1.0000	-.1751
	(16)	(16)	(16)	(16)	(16)
	P= .811	P= .267	P= .506	P= .	P= .517
COMP5	.5086	.4258	-.4323	-.1751	1.0000
	(16)	(16)	(16)	(16)	(16)
	P= .044	P= .100	P= .094	P= .517	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1	1.0000 (10) P= .	.6883 (10) P= .028	.7023 (10) P= .024	.5726 (10) P= .084	.4294 (10) P= .216
COMP2	.6883 (10) P= .028	1.0000 (10) P= .	.6833 (10) P= .029	.6482 (10) P= .043	.8250 (10) P= .003
COMP3	.7023 (10) P= .024	.6833 (10) P= .029	1.0000 (10) P= .	.6690 (10) P= .034	.4212 (10) P= .225
COMP4	.5726 (10) P= .084	.6482 (10) P= .043	.6690 (10) P= .034	1.0000 (10) P= .	.7222 (10) P= .018
COMP5	.4294 (10) P= .216	.8250 (10) P= .003	.4212 (10) P= .225	.7222 (10) P= .018	1.0000 (10) P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1	1.0000 (26) P= .	.7579 (26) P= .000	.2212 (26) P= .139	.6188 (26) P= .000	.4386 (26) P= .013
COMP2	.7579 (26) P= .000	1.0000 (26) P= .	.1011 (26) P= .312	.3909 (26) P= .024	.4215 (26) P= .016
COMP3	.2212 (26) P= .139	.1011 (26) P= .312	1.0000 (26) P= .	.2182 (26) P= .142	.6137 (26) P= .000
COMP4	.6188 (26) P= .000	.3909 (26) P= .024	.2182 (26) P= .142	1.0000 (26) P= .	.2149 (26) P= .146
COMP5	.4386 (26) P= .013	.4215 (26) P= .016	.6137 (26) P= .000	.2149 (26) P= .146	1.0000 (26) P= .

(Coefficient / (Cases) / 1-tailed Significance)

" . " is printed if a coefficient cannot be computed

GUI 2-2/3

-- Correlation Coefficients --

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1	1.0000	.5993	.1718	.7130	.6419
	(13)	(13)	(13)	(13)	(13)
	P= .	P= .030	P= .575	P= .006	P= .018
COMP2	.5993	1.0000	-.2907	.2590	.6173
	(13)	(13)	(13)	(13)	(13)
	P= .030	P= .	P= .335	P= .393	P= .025
COMP3	.1718	-.2907	1.0000	.5568	-.1231
	(13)	(13)	(13)	(13)	(13)
	P= .575	P= .335	P= .	P= .048	P= .689
COMP4	.7130	.2590	.5568	1.0000	.1809
	(13)	(13)	(13)	(13)	(13)
	P= .006	P= .393	P= .048	P= .	P= .554
COMP5	.6419	.6173	-.1231	.1809	1.0000
	(13)	(13)	(13)	(13)	(13)
	P= .018	P= .025	P= .689	P= .554	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1	1.0000	.8341	.0629	.5517	.2408
	(8)	(8)	(8)	(8)	(8)
	P= .	P= .010	P= .882	P= .156	P= .566
COMP2	.8341	1.0000	.3015	.7559	.2887
	(8)	(8)	(8)	(8)	(8)
	P= .010	P= .	P= .468	P= .030	P= .488
COMP3	.0629	.3015	1.0000	.5698	.8704
	(8)	(8)	(8)	(8)	(8)
	P= .882	P= .468	P= .	P= .140	P= .005
COMP4	.5517	.7559	.5698	1.0000	.4364
	(8)	(8)	(8)	(8)	(8)
	P= .156	P= .030	P= .140	P= .	P= .280
COMP5	.2408	.2887	.8704	.4364	1.0000
	(8)	(8)	(8)	(8)	(8)
	P= .566	P= .488	P= .005	P= .280	P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:

There exists some high correlation between all completeness questions, but only among answers given by respondents who listed their C++ programming experience level as 3, and their scientific computation programming experience level as 2 or 3. The group whose C++ programming experience is level 2, do not exhibit the same correlation among their answers.

2. For the class XYPLot:

There exists some correlation between COMP1 & COMP2, COMP1 & COMP4, COMP3 & COMP5.

Exceptions for C++ programming level 2, and GUI programming experience level 2 or 3 we find: There exists some correlation between COMP1 & COMP5, COMP2 & COMP5, COMP3 & COMP4.

Exceptions for C++ programming level 3, and GUI programming experience level 2 or 3 we find: There exists some correlation between COMP2 & COMP4, COMP3 & COMP4.

These results are summarized in the table below:

	COMP1	COMP2	COMP3	COMP4	COMP5
COMP1					
COMP2	A				
COMP3	C3	C3			
COMP4	A	A	A		
COMP5	A	A	A	C3	

C. CORRECTNESS

CORREC2
11. The methods contained in the class correctly implement the functions that the real world object performs and that this class represents.
5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

CORREC3
12. The class methods meet your expectations in terms of the number of input and output parameters.
5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

CORREC5
13. The class methods meet your expectations in terms of the types of input and output parameters.
5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All responses

-- Correlation Coefficients --

	CORREC2	CORREC3	CORREC5
CORREC2	1.0000 (33) P= .	.5230 (33) P= .001	.3728 (33) P= .016
CORREC3	.5230 (33) P= .001	1.0000 (33) P= .	.1330 (33) P= .230
CORREC5	.3728 (33) P= .016	.1330 (33) P= .230	1.0000 (33) P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3 -- Correlation Coefficients --

	CORREC2	CORREC3	CORREC5
CORREC2	1.0000	.7525	.4542
	(16)	(16)	(16)
	P= .	P= .001	P= .077
CORREC3	.7525	1.0000	.2120
	(16)	(16)	(16)
	P= .001	P= .	P= .431
CORREC5	.4542	.2120	1.0000
	(16)	(16)	(16)
	P= .077	P= .431	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 3-2/3
-- Correlation Coefficients --

	CORREC2	CORREC3	CORREC5
CORREC2	1.0000	.6740	.2647
	(10)	(10)	(10)
	P= .	P= .033	P= .460
CORREC3	.6740	1.0000	.1150
	(10)	(10)	(10)
	P= .033	P= .	P= .752
CORREC5	.2647	.1150	1.0000
	(10)	(10)	(10)
	P= .460	P= .752	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)
All responses

-- Correlation Coefficients --

	CORREC2	CORREC3	CORREC5
CORREC2	1.0000	.6737	.5988
	(26)	(26)	(26)
	P= .	P= .000	P= .001
CORREC3	.6737	1.0000	.1034
	(26)	(26)	(26)
	P= .000	P= .	P= .308
CORREC5	.5988	.1034	1.0000
	(26)	(26)	(26)
	P= .001	P= .308	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 2-2/3

-- Correlation Coefficients --

	CORREC2	CORREC3	CORREC5
CORREC2	1.0000	.4991	.7833
	(13)	(13)	(13)
	P= .	P= .082	P= .002
CORREC3	.4991	1.0000	.1174
	(13)	(13)	(13)
	P= .082	P= .	P= .702
CORREC5	.7833	.1174	1.0000
	(13)	(13)	(13)
	P= .002	P= .702	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	CORREC2	CORREC3	CORREC5
CORREC2	1.0000	1.0000	.4286
	(8)	(8)	(8)
	P= .	P= .000	P= .289
CORREC3	1.0000	1.0000	.4286
	(8)	(8)	(8)
	P= .000	P= .	P= .289
CORREC5	.4286	.4286	1.0000
	(8)	(8)	(8)
	P= .289	P= .289	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:

There exists some correlation between CORREC2 & CORREC3.

2. For the class XYPLot:

There exists some correlation between CORREC2 & CORREC3, CORREC2 & CORREC5.

These results are summarized in the table below:

	CORREC2	CORREC3	CORREC5
CORREC2			
CORREC3	A		
CORREC5	AG		

D. GENERALITY

GEN1
14. It is hard to use the class with minor modifications to build another application in a related domain.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

GEN2
15. It is hard to use the class with minor modifications to build another application in a different domain.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

GEN3
16. It is possible to use the class as is to run more than one domain-related application.
5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All responses
-- Correlation Coefficients --

	GEN1	GEN2	GEN3
GEN1	1.0000	.4024	.2925
	(33)	(33)	(33)
	P= .	P= .010	P= .049
GEN2	.4024	1.0000	.0349
	(33)	(33)	(33)
	P= .010	P= .	P= .423
GEN3	.2925	.0349	1.0000
	(33)	(33)	(33)
	P= .049	P= .423	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3 -- Correlation Coefficients --

	GEN1	GEN2	GEN3
GEN1	1.0000	.2694	.1728
	(16)	(16)	(16)
	P= .	P= .313	P= .522
GEN2	.2694	1.0000	-.0481
	(16)	(16)	(16)
	P= .313	P= .	P= .860
GEN3	.1728	-.0481	1.0000
	(16)	(16)	(16)
	P= .522	P= .860	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	GEN1	GEN2	GEN3
GEN1	1.0000	.4937	.3930
	(10)	(10)	(10)
	P= .	P= .147	P= .261
GEN2	.4937	1.0000	-.0512
	(10)	(10)	(10)
	P= .147	P= .	P= .888
GEN3	.3930	-.0512	1.0000
	(10)	(10)	(10)
	P= .261	P= .888	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	GEN1	GEN2	GEN3
GEN1	1.0000	.2567	.5123
	(26)	(26)	(26)
	P= .	P= .103	P= .004
GEN2	.2567	1.0000	.5263
	(26)	(26)	(26)
	P= .103	P= .	P= .003
GEN3	.5123	.5263	1.0000
	(26)	(26)	(26)
	P= .004	P= .003	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed
GUI 2-2/3

-- Correlation Coefficients --

	GEN1	GEN2	GEN3
GEN1	1.0000	.3841	.4818
	(13)	(13)	(13)
	P= .	P= .195	P= .095
GEN2	.3841	1.0000	.3701
	(13)	(13)	(13)
	P= .195	P= .	P= .213
GEN3	.4818	.3701	1.0000
	(13)	(13)	(13)
	P= .095	P= .213	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	GEN1	GEN2	GEN3
GEN1	1.0000	-.5136	.3612
	(8)	(8)	(8)
	P= .	P= .193	P= .379
GEN2	-.5136	1.0000	.1707
	(8)	(8)	(8)
	P= .193	P= .	P= .686
GEN3	.3612	.1707	1.0000
	(8)	(8)	(8)
	P= .379	P= .686	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:
There isn't any significant correlation between the various aspects of generality.

2. For the class XYPLot:

There exist some correlations between GEN1 & GEN3, GEN2 & GEN3.

These results are summarized in the table below:

	GEN1	GEN2	GEN3
GEN1			
GEN2			
GEN3	AG	AG	

Analysis: The generality attributes are readily apparent for the GUI class (it is not generic). However, respondents seemed to differ in evaluating the generality of the Conductor class. This may be due to a number of reasons, such as the questions were too similar, the questions were not clearly stated, the respondents had varying backgrounds/outlooks on what did or did not constitute generality in the Scientific Computation domain. Further investigation is warranted.

E. MAINTAINABILITY

MAINT1
17. It is difficult to follow the methods' text and documentation in order to understand the methods.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

MAINT2
18. It is difficult to make changes to the class methods for the purpose of making the code more run-time efficient.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

MAINT3
19. It is difficult to make changes to the class methods for the purpose of making the code more storage efficient.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All responses

- - Correlation Coefficients - -

	MAINT1	MAINT2	MAINT3
MAINT1	1.0000	.5801	.5335
	(33)	(33)	(33)
	P= .	P= .000	P= .001
MAINT2	.5801	1.0000	.5856
	(33)	(33)	(33)
	P= .000	P= .	P= .000
MAINT3	.5335	.5856	1.0000
	(33)	(33)	(33)
	P= .001	P= .000	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3 -- Correlation Coefficients --

	MAINT1	MAINT2	MAINT3
MAINT1	1.0000 (16) P= .	.6269 (16) P= .009	.5123 (16) P= .042
MAINT2	.6269 (16) P= .009	1.0000 (16) P= .	.5696 (16) P= .021
MAINT3	.5123 (16) P= .042	.5696 (16) P= .021	1.0000 (16) P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	MAINT1	MAINT2	MAINT3
MAINT1	1.0000 (10) P= .	.7110 (10) P= .021	.7285 (10) P= .017
MAINT2	.7110 (10) P= .021	1.0000 (10) P= .	.4593 (10) P= .182
MAINT3	.7285 (10) P= .017	.4593 (10) P= .182	1.0000 (10) P= .

(Coefficient / (Cases) / 2-tailed Significance)
. " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	MAINT1	MAINT2	MAINT3
MAINT1	1.0000 (26) P= .	.6900 (26) P= .000	.1026 (26) P= .309
MAINT2	.6900 (26) P= .000	1.0000 (26) P= .	.0286 (26) P= .445
MAINT3	.1026 (26) P= .309	.0286 (26) P= .445	1.0000 (26) P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 2-2/3

-- Correlation Coefficients --

	MAINT1	MAINT2	MAINT3
MAINT1	1.0000	.5681	.6117
	(13)	(13)	(13)
	P= .	P= .043	P= .026
MAINT2	.5681	1.0000	.4236
	(13)	(13)	(13)
	P= .043	P= .	P= .149
MAINT3	.6117	.4236	1.0000
	(13)	(13)	(13)
	P= .026	P= .149	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	MAINT1	MAINT2	MAINT3
MAINT1	1.0000	7737	-.7288
	(8)	(8)	(8)
	P= .	P= .024	P= .040
MAINT2	.7737	1.0000	-.8256
	(8)	(8)	(8)
	P= .024	P= .	P= .012
MAINT3	-.7288	-.8256	1.0000
	(8)	(8)	(8)
	P= .040	P= .012	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:
There exists some correlation between all maintainability responses.

2. For the class XYPLot:

There exists some correlation between MAINT1 & MAINT2.

Exceptions for C++ programming level 2, and GUI programming experience level 2 or 3 we find:
Some Correlation between MAINT1 & MAINT3.

Exceptions for C++ programming level 3, and GUI programming experience level 2 or 3 we find:
None.

These results are summarized in the table below:

	MAINT1	MAINT2	MAINT3
MAINT1			
MAINT2	A		
MAINT3	A	C	

F. MODULARITY

MOD1.1

20.1 It is difficult to add methods to the class without affecting other methods within the same class.

1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

MOD1.2

20.2 It is difficult to delete methods to the class without affecting other methods within the same class.

1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

MOD2

21. It is difficult to modify the class methods without impacting other methods within the same class.

1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

MOD3

22. It is easy to modify the class methods without impacting methods in other classes.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

MOD4

23. It is easy to change the name of class attributes without impacting methods in other classes.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

MOD5

24. It is easy to change the storage size of class attributes without impacting methods in other classes.

5 Strongly Agree **4** Agree **3** Neutral **2** Disagree **1**Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All Responses

-- Correlation Coefficients --

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1	1.0000	.5493	.1712	.0828	.0069	.2122
	(33)	(33)	(33)	(33)	(33)	(33)
	P= .	P= .000	P= .170	P= .323	P= .485	P= .118
MOD1.2	.5493	1.0000	.5764	-.0550	.2743	.1098
	(33)	(33)	(33)	(33)	(33)	(33)
	P= .000	P= .	P= .000	P= .381	P= .061	P= .271
MOD2	.1712	.5764	1.0000	-.0283	.2523	.0213
	(33)	(33)	(33)	(33)	(33)	(33)
	P= .170	P= .000	P= .	P= .438	P= .078	P= .453
MOD3	.0828	-.0550	-.0283	1.0000	.1902	.1710
	(33)	(33)	(33)	(33)	(33)	(33)
	P= .323	P= .381	P= .438	P= .	P= .144	P= .171
MOD4	.0069	.2743	.2523	.1902	1.0000	.5247
	(33)	(33)	(33)	(33)	(33)	(33)
	P= .485	P= .061	P= .078	P= .144	P= .	P= .001
MOD5	.2122	.1098	.0213	.1710	.5247	1.0000
	(33)	(33)	(33)	(33)	(33)	(33)
	P= .118	P= .271	P= .453	P= .171	P= .001	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3 -- Correlation Coefficients --

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1	1.0000 (16) P= .	.5964 (16) P= .015	.1749 (16) P= .517	-.2620 (16) P= .327	-.0332 (16) P= .903	.1658 (16) P= .539
MOD1.2	.5964 (16) P= .015	1.0000 (16) P= .	.4906 (16) P= .054	-.3126 (16) P= .238	.2231 (16) P= .406	.1593 (16) P= .556
MOD2	.1749 (16) P= .517	.4906 (16) P= .054	1.0000 (16) P= .	-.2480 (16) P= .354	.1632 (16) P= .546	.0367 (16) P= .893
MOD3	-.2620 (16) P= .327	-.3126 (16) P= .238	-.2480 (16) P= .354	1.0000 (16) P= .	-.0651 (16) P= .811	.4030 (16) P= .122
MOD4	-.0332 (16) P= .903	.2231 (16) P= .406	.1632 (16) P= .546	-.0651 (16) P= .811	1.0000 (16) P= .	.7552 (16) P= .001
MOD5	.1658 (16) P= .539	.1593 (16) P= .556	.0367 (16) P= .893	.4030 (16) P= .122	.7552 (16) P= .001	1.0000 (16) P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1	1.0000	.9347	.5455	.0564	-.0493	.2704
	(10)	(10)	(10)	(10)	(10)	(10)
	P= .	P= .000	P= .103	P= .877	P= .892	P= .450
MOD1.2	.9347	1.0000	.6095	-.0657	.0575	.3739
	(10)	(10)	(10)	(10)	(10)	(10)
	P= .000	P= .	P= .061	P= .857	P= .875	P= .287
MOD2	.5455	.6095	1.0000	.3101	.2712	.2940
	(10)	(10)	(10)	(10)	(10)	(10)
	P= .103	P= .061	P= .	P= .383	P= .449	P= .410
MOD3	.0564	-.0657	.3101	1.0000	.4709	.1287
	(10)	(10)	(10)	(10)	(10)	(10)
	P= .877	P= .857	P= .383	P= .	P= .170	P= .723
MOD4	-.0493	.0575	.2712	.4709	1.0000	.4126
	(10)	(10)	(10)	(10)	(10)	(10)
	P= .892	P= .875	P= .449	P= .170	P= .	P= .236
MOD5	.2704	.3739	.2940	.1287	.4126	1.0000
	(10)	(10)	(10)	(10)	(10)	(10)
	P= .450	P= .287	P= .410	P= .723	P= .236	P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1	1.0000	.7905	.0918	.2730	.2552	.2588
	(26)	(26)	(26)	(26)	(26)	(26)
	P= .	P= .000	P= .328	P= .089	P= .104	P= .101
MOD1.2	.7905	1.0000	.2583	.2719	.2201	.3175
	(26)	(26)	(26)	(26)	(26)	(26)
	P= .000	P= .	P= .101	P= .090	P= .140	P= .057
MOD2	.0918	.2583	1.0000	.3469	.0753	.1669
	(26)	(26)	(26)	(26)	(26)	(26)
	P= .328	P= .101	P= .	P= .041	P= .357	P= .208
MOD3	.2730	.2719	.3469	1.0000	.3348	.1518
	(26)	(26)	(26)	(26)	(26)	(26)
	P= .089	P= .090	P= .041	P= .	P= .047	P= .230
MOD4	.2552	.2201	.0753	.3348	1.0000	.5238
	(26)	(26)	(26)	(26)	(26)	(26)
	P= .104	P= .140	P= .357	P= .047	P= .	P= .003
MOD5	.2588	.3175	.1669	.1518	.5238	1.0000
	(26)	(26)	(26)	(26)	(26)	(26)
	P= .101	P= .057	P= .208	P= .230	P= .003	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 2-2/3

-- Correlation Coefficients --

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1	1.0000	.7568	.4227	.1811	.6617	.4418
	(13)	(13)	(13)	(13)	(13)	(13)
	P= .	P= .003	P= .150	P= .554	P= .014	P= .131
MOD1.2	.7568	1.0000	.5330	.4075	.7720	.3579
	(13)	(13)	(13)	(13)	(13)	(13)
	P= .003	P= .	P= .061	P= .167	P= .002	P= .230
MOD2	.4227	.5330	1.0000	.1847	.5667	.6238
	(13)	(13)	(13)	(13)	(13)	(13)
	P= .150	P= .061	P= .	P= .546	P= .043	P= .023
MOD3	.1811	.4075	.1847	1.0000	-.0821	.0625
	(13)	(13)	(13)	(13)	(13)	(13)
	P= .554	P= .167	P= .546	P= .	P= .790	P= .839
MOD4	.6617	.7720	.5667	-.0821	1.0000	.6238
	(13)	(13)	(13)	(13)	(13)	(13)
	P= .014	P= .002	P= .043	P= .790	P= .	P= .023
MOD5	.4418	.3579	.6238	.0625	.6238	1.0000
	(13)	(13)	(13)	(13)	(13)	(13)
	P= .131	P= .230	P= .023	P= .839	P= .023	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1	1.0000	.7566	-.3590	.2800	.4667	.4015
	(8)	(8)	(8)	(8)	(8)	(8)
	P= .	P= .030	P= .382	P= .502	P= .244	P= .324
MOD1.2	.7566	1.0000	-.1908	.0388	.5817	.7209
	(8)	(8)	(8)	(8)	(8)	(8)
	P= .030	P= .	P= .651	P= .927	P= .130	P= .044
MOD2	-.3590	-.1908	1.0000	.5884	.5414	.1459
	(8)	(8)	(8)	(8)	(8)	(8)
	P= .382	P= .651	P= .	P= .125	P= .166	P= .730
MOD3	.2800	.0388	.5884	1.0000	.5789	.3645
	(8)	(8)	(8)	(8)	(8)	(8)
	P= .502	P= .927	P= .125	P= .	P= .133	P= .375
MOD4	.4667	.5817	.5414	.5789	1.0000	.5564
	(8)	(8)	(8)	(8)	(8)	(8)
	P= .244	P= .130	P= .166	P= .133	P= .	P= .152
MOD5	.4015	.7209	.1459	.3645	.5564	1.0000
	(8)	(8)	(8)	(8)	(8)	(8)
	P= .324	P= .044	P= .730	P= .375	P= .152	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:

There exists some correlation between MOD1.1 & MOD1.2, MOD 1.2 & MOD2, and between MOD4 & MOD5.

2. For the class XYPLot:
There exists some correlation between MOD1.1 & MOD1.2, MOD4 & MOD5.

Exceptions for C++ programming level 2, and GUI programming experience level 2 or 3 we find: Some Correlation between MOD1.1 & MOD4, MOD 1.2 & MOD2, MOD1.2 & MOD4, MOD2 & MOD4, MOD2 & MOD5.

Exceptions for C++ programming level 3, and GUI programming experience level 2 or 3 we find: Some Correlation between MOD1.2 & MOD4, MOD1.2 & MOD5, MOD2 & MOD3, MOD2 & MOD4, MOD3 & MOD4.

Note: some correlation appears between MOD2 & MOD4, for both GUI experienced programmers (levels 2 and 3), but not in the overall data thta includes novice C++ programmers. This fact re-enforces and further justifies our decision to stratify the raw data and ignore those responses sent by novice programmers.

These results are summarized in the table below:

	MOD1.1	MOD1.2	MOD2	MOD3	MOD4	MOD5
MOD1.1						
MOD1.2	A					
MOD2		A				
MOD3			G3			
MOD4	G2	G	G	G3		
MOD5		G3	G2		A	

G. PORTABILITY

PORT1
25. The attributes used within the class methods are storage-size-dependant on the specific C++ compiler.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

PORT2
26. The attributes used within the class methods are type-dependant on the specific C++ compiler.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

PORT3
27. It is difficult to use the class on a different system configuration.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

PORT4
28. It is difficult to use the class with a different C++ compiler.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

PORT5
29. It is difficult to use the class with a different operating systems.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All responses

-- Correlation Coefficients --

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1	1.0000	.3921	.1484	.4789	.1278
	(33)	(33)	(33)	(33)	(33)
	P= .	P= .012	P= .205	P= .002	P= .239
PORT2	.3921	1.0000	.7925	.7816	.5598
	(33)	(33)	(33)	(33)	(33)
	P= .012	P= .	P= .000	P= .000	P= .000
PORT3	.1484	.7925	1.0000	.7867	.6598
	(33)	(33)	(33)	(33)	(33)
	P= .205	P= .000	P= .	P= .000	P= .000
PORT4	.4789	.7816	.7867	1.0000	.5001
	(33)	(33)	(33)	(33)	(33)
	P= .002	P= .000	P= .000	P= .	P= .002
PORT5	.1278	.5598	.6598	.5001	1.0000
	(33)	(33)	(33)	(33)	(33)
	P= .239	P= .000	P= .000	P= .002	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3

-- Correlation Coefficients --

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1	1.0000	.3187	-.0719	.4871	.0000
	(16)	(16)	(16)	(16)	(16)
	P= .	P= .229	P= .791	P= .056	P=1.000
PORT2	.3187	1.0000	.8078	.7716	.4285
	(16)	(16)	(16)	(16)	(16)
	P= .229	P= .	P= .000	P= .000	P= .098
PORT3	-.0719	.8078	1.0000	.6445	.5315
	(16)	(16)	(16)	(16)	(16)
	P= .791	P= .000	P= .	P= .007	P= .034
PORT4	.4871	.7716	.6445	1.0000	.2560
	(16)	(16)	(16)	(16)	(16)
	P= .056	P= .000	P= .007	P= .	P= .339
PORT5	.0000	.4285	.5315	.2560	1.0000
	(16)	(16)	(16)	(16)	(16)
	P=1.000	P= .098	P= .034	P= .339	P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1	1.0000	.3745	.4325	.3943	.2668
	(10)	(10)	(10)	(10)	(10)
	P= .	P= .286	P= .212	P= .259	P= .456
PORT2	.3745	1.0000	.8227	.8462	.7869
	(10)	(10)	(10)	(10)	(10)
	P= .286	P= .	P= .003	P= .002	P= .007
PORT3	.4325	.8227	1.0000	.9627	.9689
	(10)	(10)	(10)	(10)	(10)
	P= .212	P= .003	P= .	P= .000	P= .000
PORT4	.3943	.8462	.9627	1.0000	.9476
	(10)	(10)	(10)	(10)	(10)
	P= .259	P= .002	P= .000	P= .	P= .000
PORT5	.2668	.7869	.9689	.9476	1.0000
	(10)	(10)	(10)	(10)	(10)
	P= .456	P= .007	P= .000	P= .000	P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1	1.0000	.6937	.3126	.5253	.3507
	(26)	(26)	(26)	(26)	(26)
	P= .	P= .000	P= .060	P= .003	P= .039
PORT2	.6937	1.0000	.5971	.3400	.3629
	(26)	(26)	(26)	(26)	(26)
	P= .000	P= .	P= .001	P= .045	P= .034
PORT3	.3126	.5971	1.0000	.5177	.3989
	(26)	(26)	(26)	(26)	(26)
	P= .060	P= .001	P= .	P= .003	P= .022
PORT4	.5253	.3400	.5177	1.0000	.5567
	(26)	(26)	(26)	(26)	(26)
	P= .003	P= .045	P= .003	P= .	P= .002
PORT5	.3507	.3629	.3989	.5567	1.0000
	(26)	(26)	(26)	(26)	(26)
	P= .039	P= .034	P= .022	P= .002	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 2-2/3

-- Correlation Coefficients --

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1	1.0000 (13) P= .	.5567 (13) P= .048	-.1494 (13) P= .626	.2961 (13) P= .326	.2300 (13) P= .450
PORT2	.5567 (13) P= .048	1.0000 (13) P= .	.5509 (13) P= .051	.2558 (13) P= .399	.1539 (13) P= .616
PORT3	-.1494 (13) P= .626	.5509 (13) P= .051	1.0000 (13) P= .	.2609 (13) P= .389	.2336 (13) P= .442
PORT4	.2961 (13) P= .326	.2558 (13) P= .399	.2609 (13) P= .389	1.0000 (13) P= .	.9361 (13) P= .000
PORT5	.2300 (13) P= .450	.1539 (13) P= .616	.2336 (13) P= .442	.9361 (13) P= .000	1.0000 (13) P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1	1.0000	.8969	.9166	.8237	.4246
	(8)	(8)	(8)	(8)	(8)
	P= .	P= .003	P= .001	P= .012	P= .294
PORT2	.8969	1.0000	.7969	.6914	.7022
	(8)	(8)	(8)	(8)	(8)
	P= .003	P= .	P= .018	P= .058	P= .052
PORT3	.9166	.7969	1.0000	.8385	.5530
	(8)	(8)	(8)	(8)	(8)
	P= .001	P= .018	P= .	P= .009	P= .155
PORT4	.8237	.6914	.8385	1.0000	.3284
	(8)	(8)	(8)	(8)	(8)
	P= .012	P= .058	P= .009	P= .	P= .427
PORT5	.4246	.7022	.5530	.3284	1.0000
	(8)	(8)	(8)	(8)	(8)
	P= .294	P= .052	P= .155	P= .427	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:
There exist significant correlations between all portability responses among answers given by respondents who listed their C++ programming experience level as 3, and their scientific computation programming experience level as 2 or 3. The group whose C++ programming experience is level 2, do not exhibit the same degree of correlation among their answers although they are consistent with the other group's responses.

2. For the class XYPLot:

There exists some correlation between PORT1 & PORT2, PORT1 & PORT4, PORT2 & PORT3, PORT3 & PORT4, PORT4 & PORT5.

Exceptions for C++ programming level 2, and GUI programming experience level 2 or 3 we find: none.

Exceptions for C++ programming level 3, and GUI programming experience level 2 or 3 we find: Some Correlation between PORT1 & PORT3, PORT2 & PORT4, PORT2 & PORT5, PORT3 & PORT5.

These results are summarized in the table below:

	PORT1	PORT2	PORT3	PORT4	PORT5
PORT1					
PORT2	A				
PORT3	A	A			
PORT4	A	A	A		
PORT5	C	A	A	A	

H. UNDERSTANDABILITY

UNDERS1
30. It is hard to keep track of the attributes defined in the class.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

UNDERS2
31. It is hard to keep track of the number of functions implemented in each method.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

UNDERS3
32. It is hard to keep track of those methods within this class that share the same name.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

UNDERS5
33. It is hard to keep track of those classes or methods in other classes, that this class's methods impact.
1 Strongly Agree **2** Agree **3** Neutral **4** Disagree **5** Strongly Disagree **0** Not Applicable

Sorted Data: Class Conductor, Scientific Computation Domain
All responses

-- Correlation Coefficients --

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1	1.0000	.2972	.1610	.3356
	(33)	(33)	(33)	(33)
	P= .	P= .046	P= .185	P= .028
UNDERS2	.2972	1.0000	.2604	.1714
	(33)	(33)	(33)	(33)
	P= .046	P= .	P= .072	P= .170
UNDERS3	.1610	.2604	1.0000	.5815
	(33)	(33)	(33)	(33)
	P= .185	P= .072	P= .	P= .000
UNDERS5	.3356	.1714	.5815	1.0000
	(33)	(33)	(33)	(33)
	P= .028	P= .170	P= .000	P= .

(Coefficient / (Cases) / 1-tailed Significance)
" . " is printed if a coefficient cannot be computed

Scientific 2-2/3

-- Correlation Coefficients --

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1	1.0000 (16) P= .	-.1385 (16) P= .609	.2973 (16) P= .263	.2467 (16) P= .357
UNDERS2	-.1385 (16) P= .609	1.0000 (16) P= .	.2774 (16) P= .298	-.0444 (16) P= .870
UNDERS3	.2973 (16) P= .263	.2774 (16) P= .298	1.0000 (16) P= .	.6636 (16) P= .005
UNDERS5	.2467 (16) P= .357	-.0444 (16) P= .870	.6636 (16) P= .005	1.0000 (16) P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Scientific 3-2/3

-- Correlation Coefficients --

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1	1.0000	.8808	.0000	.3030
	(10)	(10)	(10)	(10)
	P= .	P= .001	P=1.000	P= .395
UNDERS2	.8808	1.0000	.0666	.1780
	(10)	(10)	(10)	(10)
	P= .001	P= .	P= .855	P= .623
UNDERS3	.0000	.0666	1.0000	.4746
	(10)	(10)	(10)	(10)
	P=1.000	P= .855	P= .	P= .166
UNDERS5	.3030	.1780	.4746	1.0000
	(10)	(10)	(10)	(10)
	P= .395	P= .623	P= .166	P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Attribute Correlations for the class XYPlot (GUI domain)

All responses

-- Correlation Coefficients --

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1	1.0000	.0181	.0167	-.2647
	(26)	(26)	(26)	(26)
	P= .	P= .465	P= .468	P= .096
UNDERS2	.0181	1.0000	.7872	.5830
	(26)	(26)	(26)	(26)
	P= .465	P= .	P= .000	P= .001
UNDERS3	.0167	.7872	1.0000	.5124
	(26)	(26)	(26)	(26)
	P= .468	P= .000	P= .	P= .004
UNDERS5	-.2647	.5830	.5124	1.0000
	(26)	(26)	(26)	(26)
	P= .096	P= .001	P= .004	P= .

(Coefficient / (Cases) / 1-tailed Significance)

" . " is printed if a coefficient cannot be computed

GUI 2-2/3

-- Correlation Coefficients --

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1	1.0000	.3373	.2285	.0000
	(13)	(13)	(13)	(13)
	P= .	P= .260	P= .453	P=1.000
UNDERS2	.3373	1.0000	.5680	.6458
	(13)	(13)	(13)	(13)
	P= .260	P= .	P= .043	P= .017
UNDERS3	.2285	.5680	1.0000	.5863
	(13)	(13)	(13)	(13)
	P= .453	P= .043	P= .	P= .035
UNDERS5	.0000	.6458	.5863	1.0000
	(13)	(13)	(13)	(13)
	P=1.000	P= .017	P= .035	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

GUI 3-2/3

-- Correlation Coefficients --

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1	1.0000	-.3054	-.2427	-.6641
	(8)	(8)	(8)	(8)
	P= .	P= .462	P= .562	P= .072
UNDERS2	-.3054	1.0000	.9604	.5613
	(8)	(8)	(8)	(8)
	P= .462	P= .	P= .000	P= .148
UNDERS3	-.2427	.9604	1.0000	.4973
	(8)	(8)	(8)	(8)
	P= .562	P= .000	P= .	P= .210
UNDERS5	-.6641	.5613	.4973	1.0000
	(8)	(8)	(8)	(8)
	P= .072	P= .148	P= .210	P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

By visually examining the correlation coefficients computed for the survey answers, we find that:

1. For the class Conductor:

There exists a significant correlation between all UNDERS1 & UNDERS2, but only among answers given by respondents who listed their C++ programming experience level as 3, and their scientific computation programming experience level as 2 or 3. The group whose C++ programming experience is level 2, do not exhibit the same correlation among their answers for these aspects of understandability.

However, both groups show some correlation between answers to UNDERS3 & UNDERS5.

2. For the class XYPLot:

There exists some correlation between UNDERS2 & UNDERS3, UNDERS2 & UNDERS5, UNDERS3 & UNDERS5.

Exceptions for C++ programming level 2, and GUI programming experience level 2 or 3 we find: None.

Exceptions for C++ programming level 3, and GUI programming experience level 2 or 3 we find: None.

These results are summarized in the table below:

	UNDERS1	UNDERS2	UNDERS3	UNDERS5
UNDERS1				
UNDERS2	C3			
UNDERS3		G		
UNDERS5		G	A	

Analysis: Upon inspection of the survey questions, we find that the aspects that do not show a correlation with each other are measuring disjoint aspects (e.g. attribute and method properties do not necessarily correlate within the same class).

5.2 Expected Results

As a result of this research, it is expected that a method will be identified and validated through an empirical study, whereby measures for a set of static, syntactic quality measurements that can be computed automatically from OO code, will empower software development managers to reach valid conclusions about the indirectly measurable quality attributes such as reliability and maintainability that have, to date, eluded measurement. Direct results that are expected of this research are:

1. The identification, via a set of properties, of a validated set of measurements for OO code components that measure static, syntactic attributes of the code.

2. The definition of a taxonomy that maps directly measurable software quality attributes to a set of quality attributes that can only be indirectly measured.

3. The identification, via an empirical study, of a validated method for the measurement of software quality attributes that cannot be measured directly from the software.

It is expected that these results will fill the gap that still exists in the area of software quality measurement thereby enabling software development managers to control production quality and cost. The method that will be validated during this research will allow the reliable certification of software artifacts, and will facilitate their reuse in a product-line manufacturing process. As a result, the software engineering field may mature in terms of acquiring a predefined set of product standards and product quality certification procedures.